FACTORS AFFECTING SEASONAL PREVALENCE OF BLOOD PARASITES IN DAIRY CATTLE IN OMDURMAN LOCALITY, SUDAN

By

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بسم اللّه الرّحمن الرّحيم

((إنّ في خلق السّموت والأرض واختلاف اللّيل والنّهار والفلك الّتي تجري في البحر بما ينفع النّاس ومآ أنزل اللّه من السّمآء من مّآء فأحيا بها الأرض بعد موتها وبثّ فيها من كلّ دآبّة وتصريف الرّياح والسّحاب المسخّر بين السّمآء والأرض لأيات لّقوم يعقلون))

صدق الله العظيم

سورة البقرة الآية (164)

dedication

to:

my family

my friends

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ABSTRACT

This study was conducted in Al-Rodwan project in Omdurman to investigate the prevalence of blood parasites in dairy cattle during different seasons; and to assess the relationship between the occurrence of blood parasites and factors of seasonal variations, level of milk production, body temperature, packed cell volume, breed, age and sex.

A total of 290 were during three seasons dry cool (100), dry hot (95) and wet hot (95). The sampling technique used was two stage cluster sampling method. The samples were examined in laboratory. Paraitological examinations included wet mount, buffy coat and thin blood film examinations were used.

The results showed that the prevalence of blood parasites during different seasons was 8%, 5.25% and 6.32% for dry cool, dry hot and wet hot seasons, respectively. The prevalence of *Theileria* species infection was found to be 7%, 5.25% and 6.32% for dry cool, dry hot and wet hot season, respectively. While the prevalence of *Babesia* species infection was only recorded in the dry cool season as (1%).

The results revealed that there was no effect (χ^2= 0.6089, p> 0.05) of season on the occurrence of blood parasites. But a strong correlation (t-test= –43.6, p< 0.05) was found between presence of blood parasites and milk yield. A positive correlation (χ^2= 111.9, p< 0.05) was also recorded

for body temperature with regard to the presence of blood parasites. Packed Cell Volume (PCV), breed, age and sex were found not to be associated with presence of blood parasites (χ^2= 3.145, p> 0.05; χ^2= 0.005, p> 0.05; χ^2= 0.222, p> 0.05 and χ^2= 0.483, p> 0.05, respectively). The results also revealed there was no effect of breed, sex and age on occurrence of blood parasites infections (χ^2= 0.005, 0.483 and 0.222, respectively). Also, there was no relationship between the presence of blood parasites and PCV (χ^2= 3.145).

الخلاصة

أجريت هذه الدراسة في مشروع الرضوان لإنتاج الألبان في أمدرمان لتقصي معدل حدوث الإصابة بطفيليات الدم في أبقار اللبن خلال فصول العام المختلفة وعلاقة بعض العوامل مثل التغيرات الفصلية ومستوى إدرار اللبن ودرجة حرارة جسم الحيوان وكبوس الدم بالإصابة بطفيليات الدم، كذلك تأثير سلالة وعمر وجنس الحيوان على القابلية للإصابة بطفيليات الدم.

أخذت 290 عينة خلال مواسم السنة الثلاثة الفصل الجاف البارد (100)، الفصل الحار الجاف (95) والفصل الحار الرطب (95). أخذت العينات بطريقة جمع العينات العنقودي ذي المرحلتين. أختبرت العينات في المعمل باستخدام الإختبارات الطفيلية.

أظهرت النتائج أن معدلات حدوث الإصابة بطفيليات الدم خلال فصول العام المختلفة هي 8٪، 5,25٪ و 6,32٪ في الفصل الجاف البارد، الفصل الحار الجاف والفصل الحار الرطب على التوالي. نسبة حدوث الإصابة بالثاليريا وجدت 7٪، 5,25٪ و 6,32٪ في الفصل الجاف البارد، الفصل الحار الجاف والفصل الحار الرطب على التوالي. بينما نسبة حدوث الإصابة بالبابيزيا سجلت فقط في الفصل الجاف البارد (1٪).

أشارت النتائج بأنه لا يوجد تأثير لفصول العام المختلفة على معدلات حدوث الإصابة بطفيليات الدم (مربع كاي= 3,145). لكن توجد علاقة قوية بين ظهور طفيليات الدم ومعدل إنتاج اللبن(قيمة ب<0,01). سجل وجود علاقة بين حدوث الإصابة بطفيليات الدم ودرجة حرارة جسم الحيوان (مربع كاي= 111,9). وجد أن كبوس الدم وسلالة وعمر وجنس الحيوان لاترتبط بظهور طفيليات الدم (مربع كاي= 3,145، 0,005، 0,222 و0,483 على التوالي). أظهرت النتائج أنه لا يوجد تأثير للسلالة وجنس وعمر الحيوان على حدوث عدوى طفيليات الدم (مربع كاي= 0,005، 0,483 و 0,222). أيضاً وجد أنه لا توجد علاقة بين ظهور طفيليات الدم وكبوس الدم (3,145).

INTRODUCTION

Animal products are of high nutritive value to man. Milk is the most important of these products which contains a lot of ingredients necessary for children and adults in both health and disease conditions. The milk is a main constituent of cheese, yoghurt and butter; and is necessary for products such as biscuits, cakes, ice creams and others.

During the last two decades, there is a large increase in milk consumption in Khartoum state, correlated to the increase in population due to big migrations to the state. The small dairy farms around the three towns are not able to cover this increase in demand. This led to establishment of many high production dairy farms. Most of the small farms are clustered forming large populations, for example Al-Rodwan and Kuku projects.

Dairy cattle used to be of local breeds, but foreign breeds of known high milk productivity were imported, such as pure foreign breeds, as life animals or semen for artificial insemination to upgrade the milk production. The foreign and cross breeds have high production level, but lack disease resistance especially in endemic areas. These animals faced a lot of health problems caused by different disease agents mainly bacteria, viruses and parasites.

Many studies were conducted on bacterial and viral diseases and control programs for most of these are applied at national level such as Rinder

pest, Contagious Bovine Pleuropneumonia, Black Quarter and Haemorrhagic Septicaemia; or at farm level for example mastitis and milk fever. This is due to the availability of vaccines and chemotherapeutic agents against these diseases. On the other hand, parasitic diseases although of major importance facing the dairy industry, yet they are not well studied. Blood parasites affect milk production due to direct effects on nutrient levels and blood components. Another problem is that the blood parasites are difficult to control due to the resistance of some of these parasites to drugs, and there is no successful vaccine application against most of blood parasites due to many factors such as antigenic variation in trypanosomes. The infection with blood parasites appeared clearly from general symptoms of diseases caused by these parasites such as decrease of production levels, emaciation, loss of appetite and jaundice. Also, animals would take time to reach the peak of production after recovery. Therefore, the objectives of this study are:

1. To determine prevalence of blood parasites in dairy cattle in Omdurman area during different seasons.
2. To assess the relationship between prevalence of blood parasites and seasons, Packed Cell Volume, milk yield, body temperature, age, sex and breed.

CHAPTER ONE
LITERATURE REVIEW

1.1 Major blood parasites

1.1.1 *Theileria* species

1.1.1.1 Origin and classification

Theileria is a blood protozoan parasite. It occurs throughout the world (FAO, 1987). In Africa, the origin of *Theileria* parasite was not established until late 1950s. However, Lewis (1943) recognized the importance of the African buffalo (*Syncerus caffer*) in the epidemiology of theileriosis in Africa. Neitz (1955, 1957) proved that the African buffalo acts as a reservoir host for *Theileria* infection to domestic animal. Furthermore, Young *et al.* (1973) showed that African buffalo acts as an important source of bovine theileriosis in many areas. They found that the carrier state of buffalo theileriosis might extent up to two years in the absence of re-infection.

The classification of the genus *Theileria* according to the revision of the Committee on Systematic and Evolution of the Society of Protozoologists (CSESP) which was published by Levine *et al.* (1980) and confirmed by DNA sequencing (Ellis *et al*., 1992) is given below.

Phylum: *Apicomplexa*

Class: *Sporozoea*

Subclass: *Piroplasmia*

Family: *Theileridae*

Genus: *Theileria*

1.1.1.2 Life cycle of *Theileria* species

The life cycle of *Theileria* species involve two components, the vertebrate host and the tick vector.

1.1.1.2.1 Life cycle of *Theileria* in vertebrate host

The schizogony stage begins when *Theileria* sporozoites (infective stages) are injected into the vertebrate host in the saliva of infected ticks (Nymphs or adults) during the feeding process. The injection of the parasites commences from day 4 to day 5 of ticks attachment on the host. It is considered to be a period of maturation of the parasites within the tick salivary gland (Walker, 1990). Within 10-30 minutes after injection, sporozoites invade different leukocytes sub-types depending on the *Theileria* species.

Inside the leukocyte the parasite develops into macroschizont and induces transformation and proliferation of the host cells (William and Dobbelaer, 1993).

Cell cycles of parasites leading to the formation of multinucleated parasites, the microschizonts (Shiels *et al*., 1997), which are equally divided over the daughter cells upon cell host division (Irvin *et al*., 1982). The microschizonts differentiate into merozoites which increase in number, leading to lymphocyte ruptures and release of merozoites. The triggers for differentiation are not well known. The merozoites become free and penetrate erythrocytes 8-10 days post infection with *T. annulata*

(Mehlhorn and Schein, 1984). Inside the red blood cells the parasites develop into the piroplasm stage, and that, depending on the species, appear as rod, comma or round shaped organisms. Piroplasms replicate inside red blood cells and newly formed merozoites proceed to infect other blood cells. Some very small merozoites change into ovoid forms. Only these ovoid forms are able to develop within the gut of a feeding tick (Mehlhorn and Schein, 1984).

1.1.1.2.2 Life cycle in the tick vector

When a clean tick (larva or nymph) feeds on an infected vertebrate host, the piroplasms-infected erythrocytes are ingested in the gut. Sexual reproduction of the parasite begins with the release of the piroplasms in the gut of the tick (Schein, 1975), resulting in the fusion of macro and microgametes (gametogony). The fusion of two gametes forms a zygote, which is the only diploid stage in the parasite life cycle (Gauer *et al*., 1995). Subsequently, the parasite invades the epithelial cell of the tick gut and undergoes differentiation into motile kinetes (Schein *et al*., 1975), which migrate through the haemolymph till they reach and invade the tick salivary glands (Mehlhorn and Schein, 1977). The sporogony stage begins when a kinete invades the salivary gland acini; usually type III acinus; (Fawcett *et al*., 1982 and Binnington *et al*., 1983) and becomes rounded (sporont in shape). The sporont then differentiates into a sporoplast. When the tick moults into the next stage (nymph or adult), and starts feeding on a vertebrate host, the sporoplasts become mature and form sporozoites (infective stage). The sporozoites are injected into the host in the saliva of the tick during the feeding process.

1.1.1.3 Transmission

Transmission by ticks takes place only after a period of feeding which is necessary for the development of the infective form of the parasite (Robertson, 1976). Sergent *et al.* (1945) referred to this period to contain the moulting process of the tick which is necessary for the development of the parasite to the stage which is infective to the bovine host.

Most of the ticks which are considered as vector for theileriosis undergo two or three host life cycle. Upon feeding on a vertebrate host they either engorge as larvae and nymphs on the first host before attaching to a second one for the adult feed or can utilize a fresh host for each blood meal. Normal ticks are infected when feeding as larvae or nymphs and transmit the parasite in the following instars. This is known as transtadial Transmission (Bhattcharyulu *et al*., 1975).

1.1.2 *Babesia* species

Organisms multiply in the red blood cells of the vertebrate host by asexual division, producing two, four or more non-pigmented amoeboid parasites.

1.1.2.1 Classification

According to Levine *et al.* (1980), confirmed by DNA sequencing (Ellis *et al*., 1992) a brief classification of *Babesia* is given below.

Phylum: *Apicomplexa*
Class: *Sporozoea*
Subslass: *Piroplasmia*
Family: *Babesiidae*
Genus: *Babesia*

1.1.2.2 Life cycle

Multiplication of *Babesia* organisms in the vertebrate host occurs in the erythrocytes by a budding process (Schizogony) to form two, four or more trophozoites. These are liberated from erythrocytes and invade other cells, the process being repeated until a large percentage of red blood cells are parasitized. The blood forms are readily transmissible by mechanical means to another animal, and these initiate a further cycle of asexual reproduction. Under natural conditions the *Babesia* species are transmitted by ticks (Smith and Kilborne, 1893).

Development and transmission in ticks is either by trans-ovarian transmission which is the only mode of transmission for one host ticks, or stage to stage transmission which becomes important in two or three host ticks.

1.1.2.3 Transmission

1.1.2.3.1 Trans-ovarian transmission

Riek (1964) considered that the parasites in red blood cells ingested early in the engorgement of a tick were either destroyed or their development was retarded until the tick was replete. Immediately on repletion erythrocytic form of the parasites were seen lying free in the gut contents. Koch (1906) described sexual union between forms, and Mackenstedt *et al.* (1990) confirmed the sexual cycle of *B. divergens* by DNA measurement. A further stage of development consisted of a spherical body containing a single peripheral nuclear mass. Riek (1964) considered that this form could be derived into discrete elongated bodies with a central chromatin dot. A second spherical form possessed two nuclei. Riek (1964) was unable to observe division into elongate bodies. These early stage represent part of a gametogenous cycle and syngamy with the

production of a zygote. The result of the union is a blunt, curved, cigar-shaped body. It assumed an ovoid shape as it grew, and subsequently it became a spherical body with a vacuolated central cytoplasm. The irregular spindle-shaped body develop in the epithelial cells to the parasitic stage which appears to undergo multiple fission. The development of the cell result in a number of small dots; each dot later collected a ring of cytoplasm around it to produce a number of a separate, oval or globular elements. The mature fission body ruptured from epithelial cell and liberate club-shaped bodies (vermicules) into the lumen of the gut. Vermicules migrate through the gut wall to the haemolymph. Forms were present in the haemolymph, the ovary and other tissues of the body and vermicules occur in mature ova. In the initial development in the egg of the tick, the vermicule were present in the yolk material. For further development vermicules enter the epithelial cells of the gut of the larvae, and here the same sequence of development occur as was seen in the epithelial cells of the gut of the mother tick. Further vermicules were liberated into the gut lumen or haemolyph, and then found in the cells of the salivary gland of the larvae.

1.1.2.3.2 Stage to stage transmission

The club-shaped forms were liberated from the host cell and migrate to the muscle sheaths of the nymphal tick where the they penetrate muscle cell, round up and divide repeatedly to form large numbers of small ovoid forms. Subsequent development occurs when the recently metamorphosed adult fed on an animal; the parasites migrate to the salivary glands, enter the cells of the acini and undergo repeated binary fission to form the large numbers of small, ovoid infective stage (Riek, 1964).

1.1.3 *Trypanosoma* species

Trypanosomes are microscopic elongated unicellular flagellates. They occur in vertebrates, principally in the blood and tissue fluids. They are transmitted by blood-sucking arthropods.

1.1.3.1 Classification

A summarized classification adopted from Levine *et al.* (1980) and Soulsby (1982) and confirmed by molecular techniques (Myler, 1993) is given blow:

Phylum:	*Sarcomastigophora*
Subphylum:	*Mastigophora*
Class:	*Zoomastigophora*
Order:	*Kinetoplastida*
Suborder:	*Trypanosomatina*
Family:	*Trypanosomatidae*
Genus:	*Trypanosoma*

Hoare (1964) has divided the genus into two sections according to differences of morphology and biology as follows:

a) Stercoraria which morphologically has a large sub terminal kinetoplast, posterior extremity tapering, free flagellum present, undulating membrane not well developed. Biologically the multiplication in the vertebrate host is discontinuous and occur in trypomatigote, epimastigote or amastigote forms. Metacyclic trypanosomes in the posterior station of the arthropod host are transmitted by contamination through faeces.

b) Salivaria has smaller kinetoplast, terminal or subterminal. Posterior extremity blunt, there may be no free flagellum, undulating membrane varying in development. Biologically multiplication in the vertebrate host is continuous in the trypomastigote stage. Metacyclic trypomastigotes in the anterior station of the arthropod host, and transmission by inoculation.

1.1.3.2 Life cycle

1.1.3.2.1 Life cycle in the vertebrate host

No sexual process has been observed in the life cycle of trypanosomes and all multiplication is by binary or multiple fission. In the Slivaria, division is chiefly in the trypomastigote stage in the blood or in the lymph glands. In a few instances other developmental stages have been detected; for example, intracellular forms have been found for species of subgenera *Nannomonus* and *Trypanozoon* (Soltys and Woo, 1969; Ormerod and Venkatesan, 1971). With the Stercoraria reproduction in the epimastigote and amastigote is usual.

As well a different developmental stage in the several species, polymorphism occurs and a variation in shape and size is seen in *T. brucei* and the three types: long, intermediate and stumpy have ascribed an essential role in the biology of the organism. It has been suggested that in the cyclically transmitted strains only the slender forms are capable of division. Wijers and Willett (1960) consider that only the stumpy forms are capable of infecting *Glossina* species.

1.1.3.2.2 Life cycle in the insect vector

With the exception of a few species, the majority of the trypanosomes undergo cyclical development in an arthropod vector. When mammalian blood containing trypomastigote forms is taken into the intestine of arthropod, subsequent development depends on whether anterior or posterior station development occurs.

1.3.2.2.1 Anterior station development

Ingested forms localize in the posterior part of the mid-gut of *Glossina* where they multiply in the trypomastigote stage for the first ten days.

Initially, the dividing forms in the mid-gut are broad with a kinetoplast midway between the nucleus and the posterior end. By days 10-11, long slender forms are produced and these migrate backwards and enter the space around the peritrophic membrane and then penetrate into the proventriculus, being found here 12-20 days after infection. They subsequently migrate anteriorly to the oesophogus and pharynx and then to the hypopharynx and salivary glands. In this situation, epimastigote forms are produced and further multiplication takes place. In another 2-5 days, the metacyclic or infective forms are produced. Metacyclic trypanosomes are small stumpy forms which some what resemble the stumpy forms in the blood. These are injected into the host with saliva when the fly bites, several thousands being injected each bite (Soulsby, 1982).

1.1.3.2.2.2 Posterior station development

Ingested trypomastigote (for example *T .lewisi*) enter cells which line the stomach of the rat flea, *Ceratophyllus fasciatus*.

Within the cells trypomastigote round up to pear-shaped organisms which increase in size while the nuclei and kinetoplast divide, ultimately giving a large number of trypomastigote forms. The cells rupture and the liberated trypomastigote stages pass from the stomach to the rectal region. During this migration they change to epimastigote forms, the kinetoplast being displaced anterior to the nucleus. The epimstigote stages attach themselves to the cells lining of the posterior gut, multiply as epimastigotes and then produce metacyclic trypanosomes. The total cycle takes about five days in the rat flea. Metacyclic trypanosomes are passed in the faeces and infection of another rat is by contamination of a flea bite wound with faeces. Alternatively, the infected flea may be ingested and then the metacyclic trypanosomes penetrate the mucous membrane of the digestive tract (Soulsby, 1982).

1.1.3.3 Transmission

Most of trypanosomes species infecting cattle have arthropod vectors in which transmission is either cyclical of an anterior or posterior station type, or a mechanical type.

Tsetse fly transmitted trypanosomiasis which is the anterior station cyclical transmission type, is the most serious constraint because the vector remains infective for a period of time (Meclennan, 1980). Seven species of tsetse fly had been recognized in Sudan out of 22 species found in Africa; these include *Glossina morsitans submorsitans*, *G. fuscipes*, *G. tachinoides*, *G. pallidepes*, *G. longipennis*, *G. fuscipleuris* and *G. fusca* (Lewis, 1949; Abdel Razig and Yagi, 1968, 1972 and Hall *et al.,* 1984).

Examples of posterior station cyclical transmission are the rat flea *Ceratophyllus fasciatus* which transmits *T. lewisi*, tabanid flies such as

Tabanus and *Haematopata* transmit *T. theileri* and sheep ked *Melophagus ovinus* transmits *T. melaphagium* (Soulsby, 1982).

On the other hand any trypanosome can be transmitted mechanically without cyclical changes taking place, and this occurs by blood-sucking insects. Experimentally, this can be done by syringe passage, and accidentally by contaminated syringes or surgical instruments.

Bovine trypanosomiasis outside tsetse belt in Sudan is mainly a problem of mechanical transmission and tabanids being the major suspect, however, efficiency of transmission varies with species of these flies (Karib, 1961; Wells, 1972 and Hall *et al.*, 1984). These vectors include the following flies: *Tabanidae*, *Muscidae* and *Hippoboscidae* found in Sudan and all these flies are common parasites of cattle, horses and other animals (Lewis, 1949, 1954; Osman and Yagi, 1972).

1.1.4 Filarial worms

All filarial worms are nematodes, stages of these worms act as blood parasite which are long and relatively thin worms. The male is frequently much smaller than the female. The worms live in the body cavities, blood, lymph vessels or connective tissues of their hosts. The larvae are known as microfilariae (Soulsby, 1982).

1.1.4.1 Classification

A brief classification of filarial worms according to Yamaguiti (1961), Chitwood (1969) and Anderson *et al.* (1974), adopted from Soulsby (1982) is:

Phylum: *Nemathelminthes*

Class: *Nematoda*

Subclass: *Secernenta*

Order: *Spirurida*

Superfamily: *Filaroidea*

Family: *Filariidae*

Family: *Setariidae*

Family: *Onchocircidae*

1.1.4.2 Life cycle

The microfilariae reach the blood stream or the tissue lymph spaces of the host, whence they may be taken up by species of arthropod intermediate host. In these intermediate hosts the larvae develop to the infective stage and, passing into the body cavity, reach the proboscis of the arthropod. When later again the fly sucks blood the larvae break their way out and enter the final host, to complete their development to adult stage. The male is smaller than female and the specules are unequal and dissimilar. The vulva is usually situated near the anterior extremity and fully developed larvae are born (Soulsby, 1982).

1.1.4.3 Transmission

Transmission of filarial worms needs arthropod intermediate host such as *Musca* species for *Parafilaria bovicola* and *Stephanofilaria* species, *Culicoides* species for *Onchocerca gibsoni* and *Anopheles gambiae* for *Setaria labiato-papillosa* (Soulsby, 1982).

1.2 Clinical and pathological changes due to infection of blood parasites in cattle

Local zebu cattle show no clinical signs of theileriosis in endemic areas, but exotic and crossbred cattle reveal enlargement of lymph nodes,

respiratory difficulty, anemia, pyremia, depressed milk yield, diarrhea, fever and body weight loss (Gill *et al*., 1977; Michael *et al*., 1989; Radostits *et al*., 2000 and Fukasama *et al*., 2002).

With *Babesia bovis* and *B. bigemina* sub-clinical infections occur fairly commonly, especially in young cattle. The a cute syndrome is characterized clinically by high fever, anorexia, depression, weakness, cessation of rumination, fall in milk yield, anemia and decrease in Packed Cell Volume (PCV) (Callow and Pepper, 1970; Smith *et al*., 1980; Patarroyo *et al*., 1995; de Vico *et al*., 1999 and Radostits *et al*., 2000).

The general clinical picture of trypanosomiasis is fever, dullness, anorexia, ocular discharges, abortion in pregnant females, diarrhea, paled mucous membranes and progressive drop in PCV resulting in anemia (Soulsby, 1982; Seifert, 1995 and Radostits *et al*., 2000).

Onchocerciasis and thelaziasis were the most important filarial infection in cattle. Infestation with *Onchcerca* species adult worms is symptomless except for the presence of subcutaneous nodules. Microfilariae induced hypersensitivity reactions include alopecia, pruritis and dermatitis. *Thelazia* species infection cause excessive lacrimatin, photophobia, conjunctivitis, keratitis, corneal ulceration and abscess formation in the eyelids (Radostits *et al*., 2000).

1.3 The effect of blood parasites and their vectors on diary cattle productivity

The effect of blood parasites and their vectors on cattle productivity differ according to several factors such as the causative agent, breed and the disease status (clinical, sub-clinical or chronic).

Many studies were conducted to study the impact of each of these factors on cattle productivity. Pholpark *et al.* (1999) studied the effect of subclinical *Trypanosoma evansi* infection on milk yield of newly introduced Holstein Friesian diary cattle; this study suggested that sub-clinical trypanosomiasis caused decrease in milk yield.

Micheal *et al.* (1989) studied the effect of treatment of chronic theileriosis on milk yields; this study suggested that treatment of diary cattle chronically infected with *Theileria annulata* using buparvaquone may have the dual beneficial effect of reducing the pathogenic effect of theileriosis, thereby permitting restoration of an impaired immune system thus increasing resistance to other infections. If a similar effect could be produced in *Bos indicus* cattle in *Theileria annulata* endemic areas, treatment of the endogenous cattle with buparvaquone could be a useful alternative to the introduction of *Bos taurus* blood as a way of boosting milk production.

Gitau *et al.* (2001) studied the impact of *Theileria parva* infections on calf mean daily weight gains; this study suggested that theileriosis exerted a temporal effect on calf-growth at the height of illness and immediately after; calves later recovered the lost growth except where other factors such as poor calf nutrition prevailed.

Scholtz *et al.* (1991) studied the effect of tick infestation on the productivity of cows of three cattle breeds: Hereford, Bonsmara and Nguni. The study showed that Herefords was the most susceptible for tick infestation, while Ngunis was the least. Thus, the effect of infestation on the productivity of Herefords was the greatest, the Bonsmaras

intermediate with the Ngunis small because a limited number of ticks fed to maturity on this breed due to its natural resistance.

Muragura *et al*. (2005) studied the incidence of calf morbidity and mortality due to vector-borne infections in smallholder dairy farms; this study suggested vector-borne diseases constrain production of replacement stock.

1.4 Factors affecting on blood parasites occurrence in cattle

The effect of several factors on blood parasites occurrence in cattle was studied by different workers. Perez *et al*. (1994) studied the relationship between the occurrence of *Babesia bovis* and *B. bigemina* and some selected factors; he stated that there was an effect of age, breed and season on the occurrence of *Babesia*.

El Mentenawy (2000) studied the effect of season on theileriosis prevalence during the study in cattle at Al-Qassim region in Saudi Arabia; he found that theileriosis prevalence reached a maximum of 84.3% in both autumn and summer seasons, while it decreased to reached 59.4% in spring.

Bakheit (1998) studied the susceptibility of Kenana cattle to tropical theileriosis in Sudan; he recorded the ability of Kenana cattle to limit the microschizont multiplication of *Theileria annulata*, resulting in less sever damage of lymphoid tissues during the acute phase of the disease which is the basis of their resistance.

Bock *et al*. (1999) studied the effect of cattle breed on innate resistance to inoculations of *Babesia bigemina*; he stated that pure bred *Bos indicus*

cattle have a high degree of resistance to babesiosis compared to *Bos indicus* cross *Bos taurus* breed and *Bos taurus* breed.

Flach *et al*. (1993, 1995) studied the effect of age and sex of cattle on susceptibility to *Theileria* species and *Babesia* species infection; he found that infection with *Theileria annulata* increased significantly with age of cattle and that there was no relationship established between infection of engorged nymphs (with *Theileria* and *Babesia*) of ticks and sex of host animal.

1.5 Epidemiology of blood parasites in Sudan

Many workers conducted research in Sudan on the scope of epidemiological aspects of blood parasites in cattle. Many of these studies discussed the evidence and prevalence of parasitic infections in different parts throughout Sudan (Khalil, 1956-1957; Abdel Malik, 1958; Uilenberg, 1960; Karib, 1961; El Bihari *et al*., 1974; Osman, 1992; Abdel Rahman *et al*., 1994 and Hassan, 2003).

The presence of bovine theileriosis has been reported all over the northern parts of the Sudan (FAO, 1983 and Osman, 1992). Furthermore, Abdel Rahman *et al*. (1994) stated that an average of 33% of exotic and cross-bred cattle referred to diagnosis at the Central Veterinary Research Laboratories (CVRL) during the period of 1983-1993 were diagnosed as suffering from theileriosis using blood smear technique. Prevalence of bovine theileriosis in different locations in Sudan was stated by Hassan (2003), who found according to blood smear technique 22.5% in Atbara, 25% in El-damer, 38% in Khartoum, 8.5% in Madani, 15.5% in Sennar, 2.7% in Um Banin, 10% in El-damazin, 2.8% in Gadarif, 8% in Kassala,

10% in Port Sudan, 13.6% in El-dueim, 16.2% in Rabak, 24.6% in Kosti, 18% in El-obied, 3.9% in Nyala, 7% in El-fasher and 8.4% in Genina.
Babesial infection in cattle has been regularly reported from all over the country and only two species of *Babesia*, *B. bovis* and *B. bigemina* had been reported to occur in Sudanese cattle (Animal Wealth Administration 1960-1981 and FAO-Tick and Tick borne diseases Control Project 1983, Sudan). *Babesia bovis* and *Babesia bigemina* were identified at Sagadi area in the White Nile Province (Abdalla, 1984).

The early indication of prevalence of trypanosomiasis in the Sudan was recorded in the Annual Veterinary Report (1904) from a herd of cattle that arrived Khartoum from the Upper Nile area. Khalil (1956-1957) mentioned that trypanosomiasis in Blue Nile Province was prevalent mostly among Kenana cattle. Uilenberg (1960) stated that *Trypanosoma vivax* was found in Kosti and El-dueim districts and *Trypanosoma congolense* was found in Aba Island. Karib (1961) recorded that trypanosomiasis was prevalent in Gadaref, Aba Island, Kosti, Malakal and Bor.

Occurrence of bovine filariasis was observed in peripheral blood in Sudanese cattle. Dominant pecies were those of *Setaria* and *Onchocerca armillata* (Abdel Malik, 1958). El Bihari *et al*. (1974) reported the incidence of microfilariae in cattle in Khartoum. The location of microfilariae of *Onchocerca armillata* was studied and determined (El Bihari and Hussein, 1975, 1976). Atta Elmannan (1981) stated that the prevalence of skin microfilariae in cattle in Sudan was 35%.

1.6 Control

Control of the blood parasites can be achieved by methods directed at causative agents, the vectors and by using resistant animals.

1.6.1 Control of the causative agents

The most important control measure for the causative agents is the use of chemotherapy.

In theileriosis tetracycline antibiotics are effective only at the early stages of the disease (Radley, 1981). Primidine (Primidine phosphate) is only effective against the piroplasm stage in the erythrocytes (Brown, 1990). Halofuquinone and naphthoquinone (parvaquone and buparvaquone) are the best to control acute theileriosis (Schein and Voigt, 1979).

Quinuronium derivatives are effective against larger babesiae; besides parvaquone, buparvaquone, alovaquone and tetracycline (Radostits *et al.*, 2000).

The common drugs in use against trypanosomiasis are diminazene aceturate (berenil), homidium bromide (ethidium), homidium chloride (novidium), isometamidium (samorin), pyrithidium bromide (prothridium), quinapyramine sulphate (antrycide) and suramin (naganol) (Radostits *et al.*, 2000).

Control of filariasis depends mainly on chemotherapy with ivermectin which has been very successful in eliminating the disease. The drug does not eliminate transmission (Borsboom *et al*., 2003 and Richards *et al*., 2005) nor kill adult worms (Bronsvoort *et al.,* 2005).

1.6.2 Control of vectors

There are methods currently used in controlling vectors of blood parasites chemically, biologically or by herd management.

1.6.2.1 Chemical control

Chemical control of vectors depends on application of acaricides and insecticides.

The chemical control methods of ticks through acaricides application are dip vats, hand spraying and spray races. Examples of this acaricides are chlorinated hydrocarbons, amidines, synthetic pyrethroides and ivermectins (George, 1987).

Tsetse control largely depends on the use of insecticides both residual e.g. Dichloro Diphenyl Trichloroethane (DDT) and non-residual e.g. Endosulphan. Residual treatments are applied to fly resting sites. Non-residual insecticides need repeated applications (Maclennan and Cook, 1972).

Pour-on method is used also for Tsetse control by using many chemicals such as cyfluthrin (van den Bossche and de Deken, 2004), pyrethroids (Eisler *et al.*, 2003) and lambdacyhalothrin (Batawui *et al.*, 2002) which is used in control of both flies and ticks.

Traps impregnated with insecticides are used in control; these traps include biconical traps, beta traps and pyramidal traps. Recently F3 trap, canopy trap, NGU trap and Epsilon trap which catch two to three times greater than others are also used (Kasilagila, 2003).

1.6.2.2 Biological control

With regards to the disadvantage of application of chemicals in control such as environmental pollution, food contamination and development of

resistance to acaricides and insecticides; the development of alternative methods of vectors control are prompted. These alternative biological control methods include pathogens, genetic methods and the sterile insect technique.

1.6.2.2.1 Pathogens

Several entomopathogenic fungi were found to be affecting ticks and flies under laboratory conditions. Laboratory bioassays have shown that the fungus *Metarhizium anisopliae* had a high pathogenicity on ticks when the adult unfed stages of the ticks were treated with formulations containing fungal spores (Micheal *et al*., 2001). Tsetse fly *Glossina morsitans morsitans* and some tabanid flies are affected when infected with *Beauveria bassiana* fungus which causes mortalities (Kaaya, 1989). Filariasis vectors can also be controlled by using the fungus *Metarhizium anisolpiae* (Scholte *et al*., 2003).

Entomopathogenic nematodes particularly those belonging to the families *Steinerinimatidae* and *Heterorhabditidae* have been found to be effective as biological control agents against many insects and arthropod pests (Kocan *et al*., 1998; de Doucet *et al*., 1999 Kaaya *et al*., 2000).

1.6.2.2.2 Genetic control

Controlling arthropods through genetical means such as hybrid sterility, cytoplasmic incompatibility, lethal factors and changing the vector mid-gut environment were tried (Knipling *et al.,* 1968 and Aksoy, 2003).

1.6.2.2.3 Sterile insect technique

The technique relies on the rearing of the target insect in large numbers in specialized production centers, the sterilization with ionizing radiation of

one of the sexes and the sustained sequential release of the sterilized insects over the target area (Vreysen, 2001).

1.6.2.3 Control through herd management

Management is an important method of control aimed to manage livestock to limit contact between susceptible stocks and the disease.

Rotational grazing and also called pasture spelling is an effective method of tick control (Wharton *et al*., 1969 and Elder *et al*., 1980). Destruction of tick microhabitat is useful for breaking tick life cycle (Hair and Howell, 1970 and Schulze *et al*., 1988).

Reducing incidence of trypanosomiasis can be done through limiting the movement of the host in endemic areas to avoid reservoirs especially wild animals which act as a source of many blood parasites (Young *et al.*, 1973 and Omer *et al*., 2004).

1.6.3 Control by resistant animal breeds

An increased interest has been directed towards an approach of blood parasites control based on both the utilization of animal breeds, which are observed to express resistance to blood parasites and their vectors; and induction of immune response based resistance against these parasites.

1.6.3.1 Naturally resistant animals

On exposure to blood parasite or arthropod infestation, an observed phenomenon during the parasite-host relationship is the development of resistance against this parasite. This resistance appears to be maintained

on subsequent infestation with the same parasite species and sometimes shows ability to cross react with other parasite species (Rechav *et al*., 1989, 1991; Wikel, 1996; Bock *et al*., 1997, 1999; Bakheit, 1998 and Seck *et al*., 2002).

Many researchers conducted trials to investigate the degree of resistance or susceptibility of *Bos indicus* and *Bos taurus* cattle. It is generally accepted that *Bos indicus* cattle are more resistant than *Bos taurus* cattle to blood parasites and their vectors, such as tick infestation and theileriosis (Brown, 1990 and Norval *et al*., 1992), babesiosis (Bock *et al*., 1997, 1999) and trypanosomiasis (Latif and Jongejan, 2002; Seck *et al*., 2002 and van der Waaij, 2003).

1.6.3.2 Artificially resistant animals

Artificial induction of immune response by cattle vaccination against vector and blood parasite started recently.

Vaccines against theileriosis developed by recent techniques such as schizont cell culture vaccine (Singh *et al*., 2001), subunit vaccine (Jenkins, 2001) and attenuation of *Theileria* virulence in schizont infected cells (Shkap *et al*., 2003).

Vaccination against babeiosis resulted in reduction of babesiosis incidence (Jittapalapong *et al*., 2004) and gave protective levels of antibodies against it (Alvares *et al*., 2004 and Shkap *et al*., 2005).

Control of ectoparasites by host immunization utilizing different parts of arthropods took recently. As for ticks, immunization has been attempted by many researchers using different tick tissues like salivary glands, mid-

gut extracts and organs of the excretory system (Wikel and Whalen, 1986; Wikel, 1988; Tellam *et al*., 1992 and Astigarraga *et al*., 1995). In Sudan, Hassan (2004) evaluated a commercial recombinant anti-tick vaccine (Gavac™) against *Hyalomma* species which induced a significant degree of protection.

CHAPTER TWO
MATERIALS AND METHODS

2.1 Area of study

Omdurman district was chosen as the area of this study. It is located in central Sudan in Khartoum State on the west bank of the White Nile and River Nile, around 12 kilometers of a radius latitude 15° 38'N and longitude 32° 26'E (Figure 2.1). The climate of Omdurman is a semi-dessert arid type characterized by a wide range in daily and seasonal temperatures. The mean daily temperature is 20.4°C in the evening and 38.2°C during the day with extremes of 44.2°C in May and 12.9°C in January. During the cool season in November to February the weather is cool and dry with a mean daily temperature of 13.7° to 32.4°C, the season is characterized by low humidity. A hot dry weather prevails during April to July, with a mean daily temperature of 25.4° to 43°C. During the hot wet season the rain fall reaches its maximum during the period from mid July to mid September, in this rainy season there is increase in relative humidity, with a maximum rain fall of 128.2 mm in August. Monthly mean temperature and relative humidity during the period from January to September 2005 was obtained from Metrological Authority, Ministry of Aviation (2005) (Table 2.1).

Al-Rodwan project in Omdurman was chosen to screen diary cattle for blood parasites. It is located on the North Western site of the locality on

an area of 100 feddans (Plate 2.1). It is the main dairy cattle aggregation site in the area with approximately 5,000 head according to the record of Ministry of Agriculture, Animal resources and Irrigation, Khartoum State (2003).

Figure (2.1): Map of Omdurman and study area location

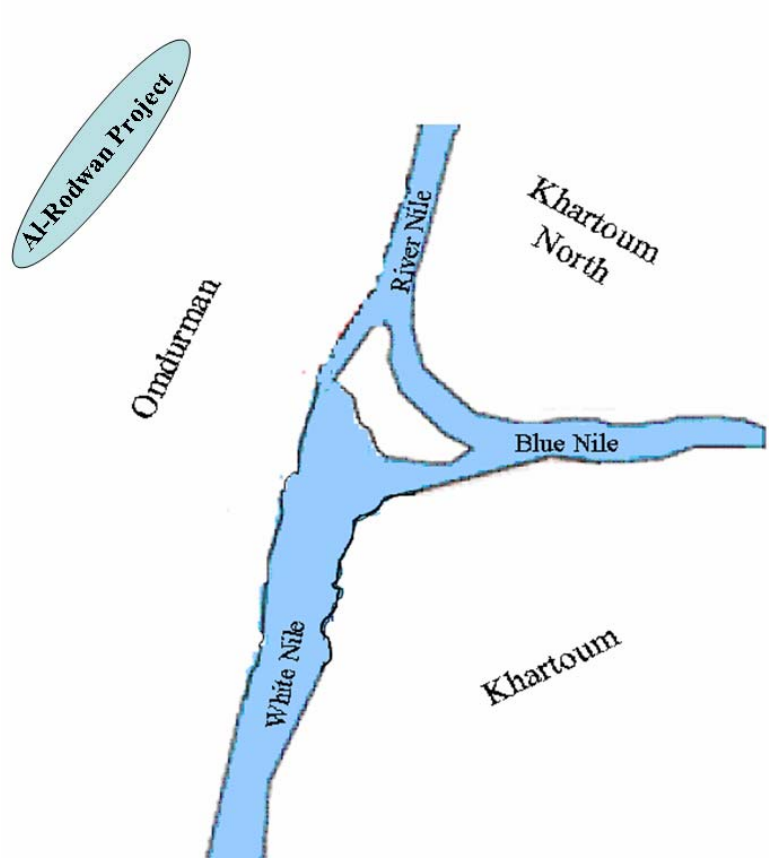


Table (2.1): Monthly mean temperature, relative humidity and total rain fall during the period January to September, 2005

Month	Mean Temperature (°C)		Relative Humidity (%)	Total Rain Fall (mm)
	Maximum	Minimum		
January	31.9	13.2	27	0.0
February	33.0	13.8	25	0.0
March	37.1	16.7	15	0.0
April	41.1	21.1	16	Trace*

May	44.2	25.1	21	24.0
June	41.1	25.1	31	8.3
July	41.7	25.7	37	12.0
August	39.9	24.1	45	138.2
September	40.4	25.2	35	30.0

* Rain fall < 0.1 mm

Plate (2.1) General view of Al-Rodwan dairy project

2.2 Production system and management

Cross breeds constituted the majority of cattle population while local breeds constituted the minority. This population was distributed in small herds managed by different owners. Herds are housed in farms primitively built with mud, wood, stone blocks and sometimes metals (Plate 2.2). The requirement of shade was not enough as a roof, which is located in the center of each farm; therefore, animals were found crowded under the shaded area during day hours (Plate 2.3). Animals were fed daily on green roughages and concentrates which were brought from the market. Application of acaricides (such as chlorinated hydrocarbons and ivermectines) and administration of anti-piroplasmal drugs (such as parvaquones) take place at intervals. The calves were separately houses in a very small places within the farm (Plate 2.4). In each farm there was a bull kept for natural insemination. Some of the dairy cattle were brought from Gezira and White Nile areas and there was a continuous

replacement of animals which corresponded to the continuous culling of some old or low producing ones. Record keeping is very poor.

2.3 Study population

Selected cattle from dairy farms in Al-Rodwan project were investigated during dry cool (February-March), dry hot (May-June) and wet hot (August-September) seasons. A hundred animals from the chosen herds of animals were studied during the above seasons. The majority was of cross breeds (89%) and the rest of the chosen population was of local breeds (11%). The population structure consisted of 81% females and 19% males. They were grouped into three age groups namely: <1 year (calves), 1-3 years (heifers) and >3 years (producing animals) giving a percentage of 33%, 4% and 63%, respectively (Table 2.2).

Plate (2.2) A cattle house at Al-Rodwan dairy project: an outer view

Plate (2.3) Internal view of a cattle house at Al-Rodwan dairy project showing a limited shaded area

NB:

Bad roof.

Limited space.

Calve from different breeds

Plate (2.4) View of calves' houses

Table (2.2): Description of study population in Al-Rodwan dairy project

Unit	Season		
	Dry cool	Dry hot	Wet hot
	Frequency (%)		
Total animal examined	100(100)	95(100)	95(100)
Breed			
Local	11(11)	11(11.58)	11(11.58)
Cross	89(89)	84(88.42)	84(88.42)
Sex			
Male	19(19)	14(14.74)	14(14.74)
Female	81(81)	81(85.26)	81(85.26)
Age			
<1 year	33(33)	28(29.47)	28(29.47)

1-3 years	4(4)	4(4.21)	4(4.21)
>3 years	63(63)	63(66.32)	63(66.32)
Milk yield			
<4 Kg	5(5)	5(5.26)	5(5.26)
4-8 Kg	39(39)	39(41.05)	39(41.05)
>8 Kg	22(22)	22(23.16)	22(23.16)

2.4 Sampling

The sampling was done according to cluster sampling method (two stage sampling) as described by Thrusfield (1995). Twenty percent of the clusters (farms) were selected randomly, and within each farm only 10% of the herd was sampled randomly to give a total of 100 animals out of 5,000 in 50 farms. The ear tag number of each animal included was recorded together with its age , sex and breed.

2.5 Sample collection

A total of 290 blood samples were collected during the three different seasons (Table 2.3) from the same animals identified. The blood was collected in the morning from the jugular veins using vacutainers with EDTA. The samples were labeled with animal number, placed in an ice box at 4ºC and transported as soon as possible to the laboratory before processing for parasitological examinations. Body temperature of the animal was taken directly from the rectum using a thermometer. The milk yield of producing animals was taken from the farm records.

2.6 Parasitological examinations

Parasitological examinations included wet blood examination, buffy coat and thin blood films examination.

2.6.1 Wet mount (King, 1976)

One drop of fresh blood was placed on a slide, covered with a cover slip and examined microscopically for detection of motile parasites at 10×40 magnification.

Table (2.3): The total number of animals examined during different seasons

No. of animal examined	Season	Months
100	Dry cold	February-March
95	Dry hot	May-June
95	Wet hot	August-September
Total: 290		

2.6.2 Buffy coat examination (Woo, 1970)

A capillary tube was taken; the end of capillary tube was put on a drop of the blood sample, filled to about three-quarters and sealed by plastoseal at one end. It was placed in the haematocrit centrifuge which was run for five minutes. After centrifugation the Packed Cell Volume was read, and then the capillary tube was placed onto a clean slide and covered with a one drop of distilled water and examined microscopically at 10×40 magnification to detect trypanosomes and microfilariae.

2.5.3 Thin blood film (King, 1976)

A small drop of fresh blood was put in the middle of one end of the slide, and spread right across the slide and then air dried. The slide was labeled using a pencil. Blood films were fixed in absolute methyl alcohol for two minutes, stained in 5% diluted Giemsa's stain for 45 minutes, and washed in distilled water and then dried. Immersion oil was put on the blood film and examined microscopically for the detection of the blood parasites at 10×100 magnification.

2.7 Data analysis

Microsoft Excel (Windows 2003) and Stata 6.0 for Windows 98/95/NT were used for data analysis. Chi-square (χ^2) was used for as a statistical analysis tool to assess the effect of various factors (body temperature, age, sex, breed and PCV). The student t-test was also employed to find out the effect of blood parasites on milk yield.

CHAPTER THREE
RESULTS

The presence of blood parasites in cattle in Al-Rodwan dairy project was investigated during different seasons. The results showed that 8 (8%) , 5 (5.25%) and 6 (6.32%) for dry cold, dry hot and wet hot, respectively were recorded as positive for blood parasites using thin blood film. All results are summarized in table (3.1). No motile organisms *Trypanosoma* and microfilaria were detected.

The prevalence of *Theileria* species infection was 7%, 5.26% and 6.32% in dry cold, dry hot and wet hot seasons, respectively. Prevalence of *Babesia* species infection was only recorded in dry cool season as 1% (Table 3.2).

There was no effect of season (χ^2= 3.145, p> 0.05) on the presence of blood parasites (Figure 3.1)

There was no relationship (χ^2 = 3.145, P >0.05) between Packed Cell Volume (PCV) and occurrence of blood parasites (Figure 3.2).

A positive correlation (p< 0.01) was found between presence of blood parasites and milk yield of cows resulting in reduction in milk production (Figure 3.3).

A strong correlation was recorded between temperature and occurrence of blood parasites (χ^2= 111.2, p< 0.01) (Figure 3.4).

No association was found to occur between presence of blood parasites and breed or sex (χ^2= 0.005, p> 0.05 and χ^2= 0.483, p> 0.05, respectively) (Table 3.3).

Age was also not found related with occurrence of blood parasites (χ^2= 0.222, p> 0.05) (Table 3.3)

Table (3.1): Summary of the result of blood parasites survey in dairy cattle in Al-Rodwan Dairy Project

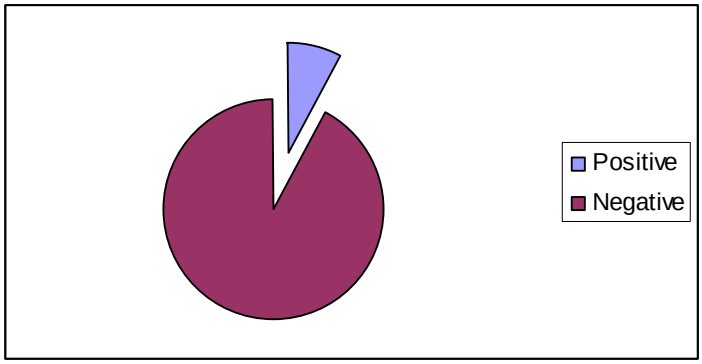
Unit	Season		
	Dry cool	Dry hot	Wet hot
	Frequency (%)		
Total of animal examined	100(100)	95(100)	95(100)
PCV			
Normal	32(32)	36(37.89)	32(33.68)
Abnormal	68(68)	59(62.11)	63(66.32)
Buffy coat			
Positive	0(0)	0(0)	0(0)
Negative	100(100)	95(100)	95(100)
Wet mount			
Positive	0(0)	0(0)	0(0)
Negative	100(100)	95(100)	95(100)
Thin blood stain			

Positive	8(8)	5(5.26)	6(6.32)
Negative	92(92)	90(94.74)	89(93.68)

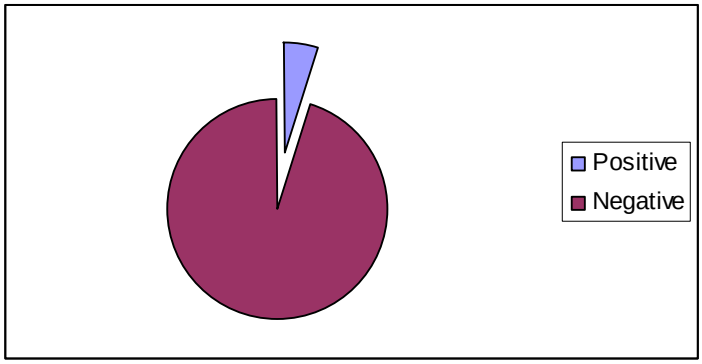
Packed Cell Volume (PCV): Adults: normal 28.4-38.8. Calves: normal 32.0-39.7,

Table (3.2): The Prevalence of blood parasites during seasons in dairy cattle in Al-Rodwan Dairy Project

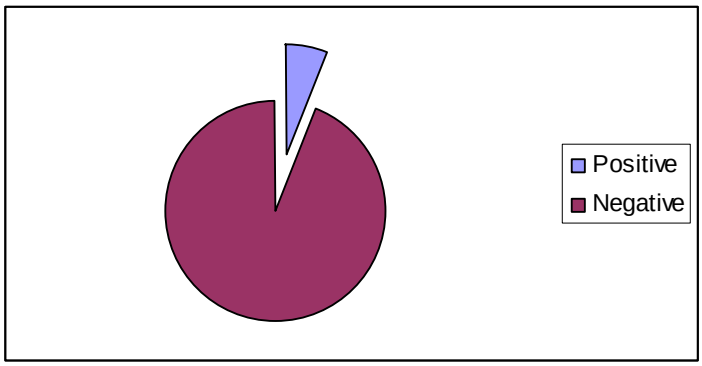
Season	**No. of animal examined**	**Prevalence (%)**		**Over all prevalence (%)**
		***Theileria* spp**	***Babesia* spp**	
Dry cool	100	7	1	8
Dry hot	95	5.26	0.00	5.26
Wet hot	95	6.32	0.00	6.32



The prevalence of blood parasites infections in dry cold season was 8%



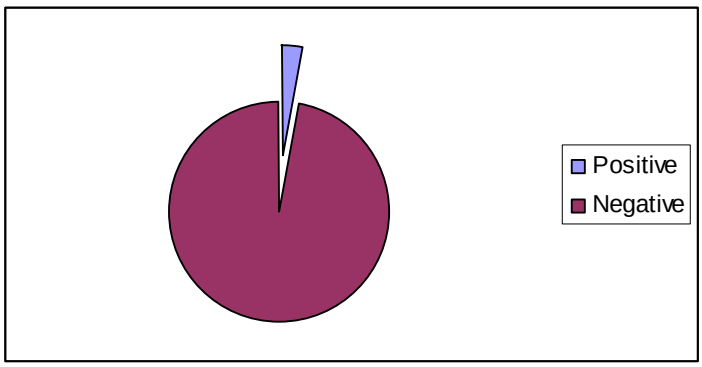
The prevalence of blood parasites infections in dry hot season was 5%



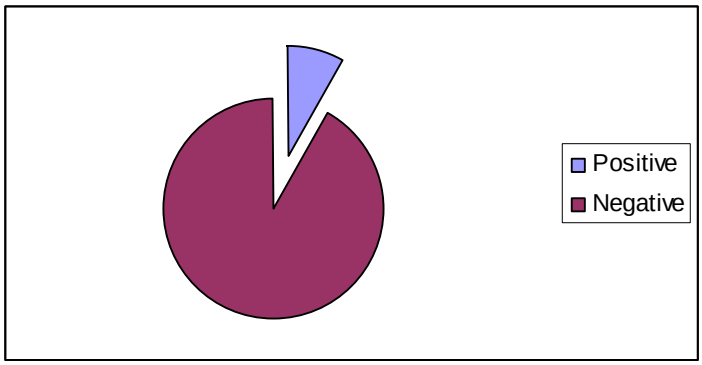
The prevalence of blood parasites infections in wet hot season was 6%

Chi-square (χ^2) =0.609 *P*-value = 0.738 (Not significant, $P > 0.05$)

Figure (3.1): The effect of season on presence of blood parasites in dairy cattle in Al-Rodwan Dairy Project



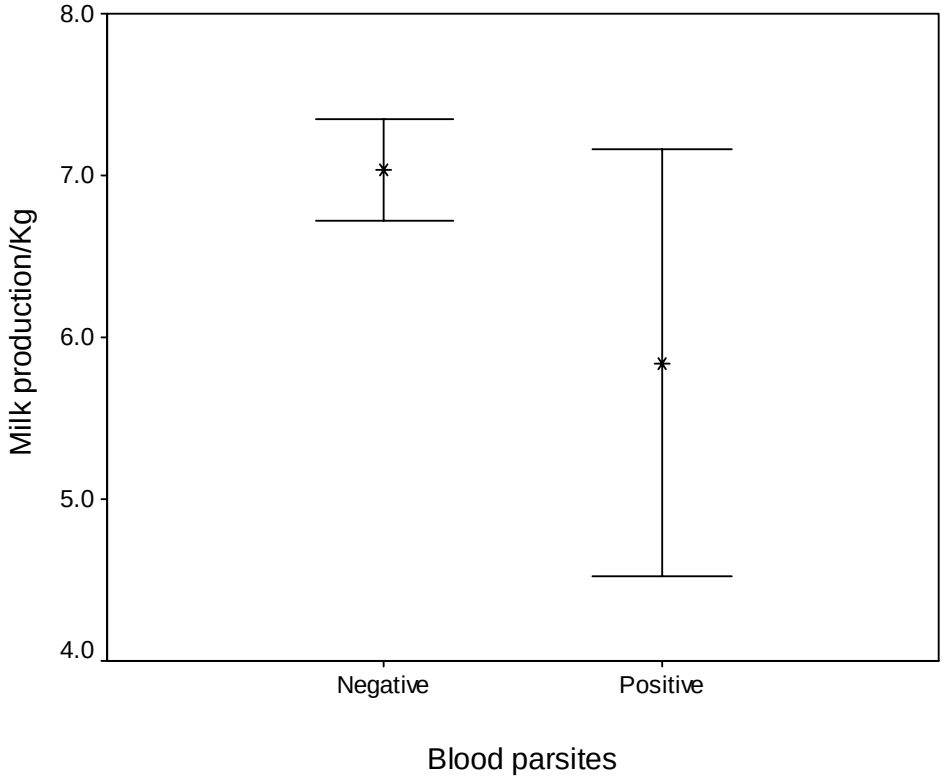
The number of positive blood parasites animals in normal PCV was 3 of 100



The number of positive blood parasites animals in abnormal PCV was 16 of 190

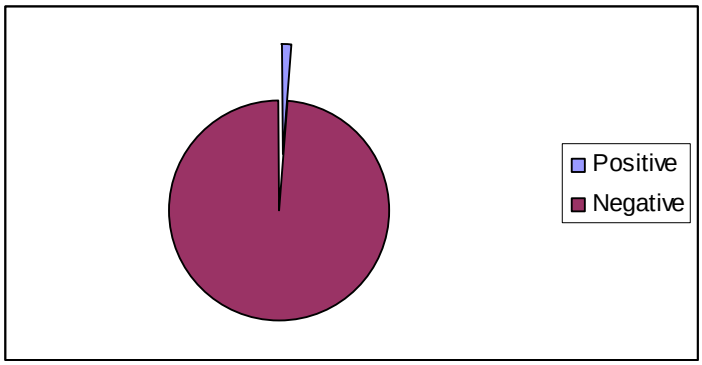
Chi-square (χ^2) = 3.145 *P*-value = 0.076 (Not significant, $P > 0.05$)

Figure (3.2): The relationship between Packed Cell Volume (PCV) and occurrence of blood parasites in dairy cattle in Al-Rodwan Dairy Project

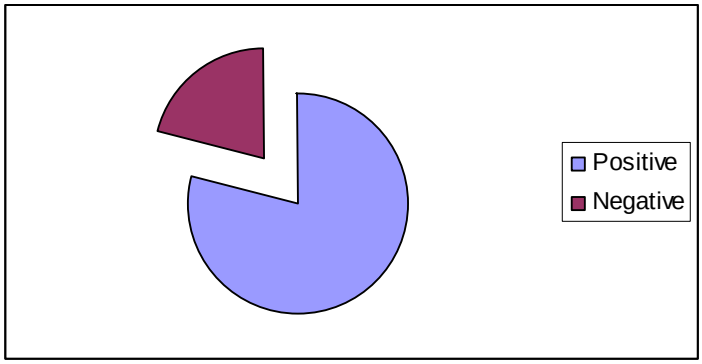


High significance ($P < 0.01$).

Figure (3.3): The relationship between blood parasites and milk production in Al-Radwan dairy farm



The number of positive blood parasites animals in normal temperature was 4 of 272



The number of positive blood parasites animals in abnormal temperature was 15 of 19

Chi-square (χ^2) =111.2 *P*-value = 0.000 (High significant, $P < 0.01$)

Figure (3.4): The relationship between body temperature and occurrence of blood parasites in dairy cattle in Al-Rodwan Dairy Project

Table (3.3): The relationship between breed, sex and age and occurrence of blood parasites in dairy cattle in Al-Rodwan Dairy Project

Factor	Chi-square (χ^2)	*P*-value
Breed	0.005	0.942
Sex	0.483	0.48
Age	0.222	0.09

CHAPTER FOUR
DISCUSSION

The study of blood parasites in dairy cattle during different seasons in Omdurman area revealed a higher prevalence of *Theileria* species infection compared to *Babesia* species infection. Similarly, different workers recorded the presence of blood parasites in both intensive and pastoral production systems of Sudan. Hassan (2003) explained that *Theileria annulata* infection is one of the most important diseases of dairy cattle in Khartoum reaching a prevalence of 38%. According to FAO report (1983), sero-epidemiological surveys revealed antibodies against *Theileria annulata* infection in 39% of the cattle in Northern Sudan. Furthermore, Abdel Rahman *et al*. (1994) stated that an average of 33% of exotic and cross-bred cattle referred for diagnosis at the Central Veterinary Research Laboratories (CVRL) during the period 1983-1993 were diagnosed to have theileriosis.

On the other hand, Abdallah (1984) found *Babesia bovis* and *Babesia bigemina* at Sagadi area in the While Nile State during an outbreak of red water disease. Animal Wealth Administration annual reports (1960-1981) and FAO-Tick and Tick borne diseases Control Project terminal report (1983) explained that babesial infection had been regularly reported in Sudanese cattle from all over the country and mainly *Babesia bovis* and *Babesia bigemina*.

The presence of blood parasites infection in dairy cattle in Al-Rodwan project was attributed to the fact that most of the farms in this area were infested with ticks; particularly, all the farms built of mud and block stones which constitute a suitable environment for that ticks.

Our study revealed that there was no effect of season (χ^2= 3.145, p> 0.05) on the prevalence of blood parasites. This finding disagreed with the results of different researchers. Perez *et al*. (1994) found that season was a risk factor of presence of *Babesia bovis* infection. El Mentenawy (2000) found during a study aimed at investigating the parasites infecting cattle blood at Al-Qassim region in Saudi Arabia, that theileriosis prevalence reached a maximum in (84.3%) in both autumn and summer seasons, while it dropped to 59.4% in spring. The disagreement of this study could be attributed to application of acaricides and administration of anti-piroplasmal drugs by farm owners at intervals, which could have affected the prevalence of blood parasites during different seasons. It could also be due to the mismanagement practiced at Al-Rodwan while allows for continuous tick challenge throughout the year.

Negative relationship was obtained between the Packed Cell Volume (PCV) and occurrences of blood parasites (χ^2= 3.145, P> 0.05). In contrast, many researchers explained that there was a positive relationship between occurrence of blood parasite and PCV. Gill *et al*. (1977) stated that *Theileria annuata* infection caused anemia. Also, Fukasama *et al*. (2002) recorded that *Theileria orientalis sergenti* infection is one of the most harmful anemic disease. Bovine babesiosis showed decrease in PCV and caused sever anemia (Callow and Pepper, 1970; de Vico *et al*., 1999 and Rodistits *et al*., 2000). The disagreement could be attributed to the fact that most of cattle population in Al-Rodwan project (68%) were found to have a low PCV which could be nutritional or due to other infections. That means there were other diseases and factors causing anemia such as internal parasites and nutritional insufficiency. This finding is very important as the health care in dairy farms need to have a defined protocol in Sudan which can be followed by farmers.

This study revealed that there was an association ($p< 0.01$) between presence of blood parasites and milk yield of producing animals. Similar results were reported by different researches. Michael *et al*. (1989) studied the effect of theileriosis on milk yield and suggested that it caused decrease in milk yield. Patarroyo *et al*. (1995) stated that bovine babesiosis caused by *Babesia bigemina* remains a significant constraint to milk cattle production. Although we could not link PCV with blood parasites, yet this could be one of the major factors that affect milk yield.

As seen from the results, there was a strong correlation ($\chi^2= 111.2$, $p< 0.01$) between occurrence of blood parasites and body temperature. Similarly, many researchers recoded this result such as de Vico *et al*. (1999), who stated that bovine babesiosis showed fever; also Smith *et al*. (1980) recorded *Babesia bovis* infection characterized by high fever. Rodistits *et al*. (2000) explained that bovine theielriosis and babesiosis caused increase in body temperature. Disturbed normal physiology during body temperature rise could result, among other things, in reduced milk production.

Our study revealed that there was no effect ($\chi^2= 0.005$, $p> 0.05$) of breed on occurrence of blood parasites. This result disagreed with different researchers. For instance, Bakheit (1998), reported that the ability of the Kenana cattle to limit the microschizont multiplication of *Theileria annulata*, resulting in less sever damage of lymphoid tissues during the acute phase of the disease was the basis of their resistance. Also Bock *et al*. (1999) stated that pure breed *Bos indicus* cattle have a high degree of resistance to babesiosis compared to *Bos indicus* cross *Bos taurus* breed and *Bos taurus* breed. The disagreement of this study could be attributed to the different breeds in the study particularly; most of the cattle

populations in diary farms in Al-Rodwan project were cross breeds (89%). The low number of pure local breeds did not allow the finding of a significant difference between the two breeds included. Also no pure foreign breed was encountered in this project.

No correlation (χ^2= 0.483, p> 0.05) was found in our study between sex and presence of blood parasites. Similar results were reported by Flach *et al*. (1993), who stated that there was no relationship was established between infection of engorged nymphs of ticks and sex of host animal. Thus sex is not a determining factor in susceptibility to tick-borne parasites.

This study revealed no relationship (χ^2= 0.222, p> 0.05) between prevalence of blood parasite and age of animals. In contrast, Flach *et al*. (1995) stated that infection with *Theileria annulata* increased significantly with age of cattle, although the age effect on new infections may be a result of increased tick numbers on older animals. Perez *et al*. (1994) revealed that age was a risk factor in the presence of *Babesia bovis* infection. The disagreement with this study could be attributed to the composition of study cattle. Most of the cattle population in diary farms in Al-Rodwan project was producing cows over three years (63%) and the rest of population were heifers (4%) and calves (33%). Also it could be due to some degree of enzootic stability where all age groups are equal in the morbidity of infection.

Other blood parasites, particularly Trypansoma or microfilaria were not encountered during this study, although reported in other parts of the capital Khartoum. Possible explanation is that Al-Rodwan project is found in an area where present conditions are not suitable for insect

propagation. This should not be overlooked as micro-climates may be created through negligence and lack of awareness and that used permit the infestation of insect species that are known as mechanical or biological vectors of some parasites. This may come as a result indiscriminate introduction of cattle which may originate from infected herds e.g. with *Trypanosoma* species or microfilaria

In conclusion, infection with *Theileria* species and *Babesia* species were prevalent in Omdurman. Infection with blood parasites had economic impact due to reduction in milk production. Based on that it is strongly recommended that more investigations are needed to find out the relationship between season and presence of blood parasites infection in dairy farms. Control of tick infestation is very important in order to avoid infections of blood parasites in dairy farms.

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